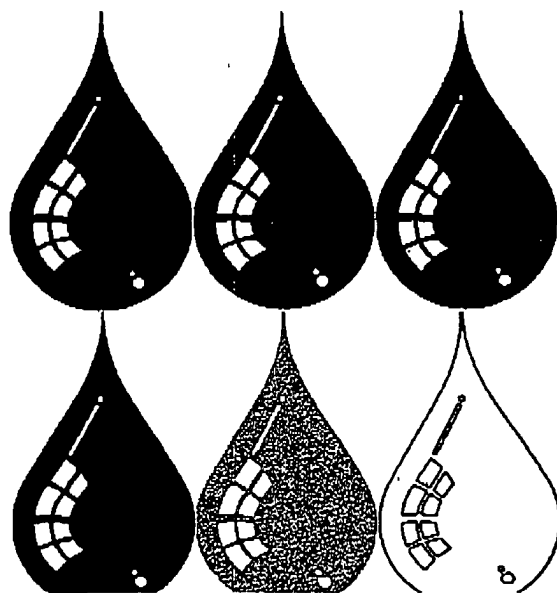
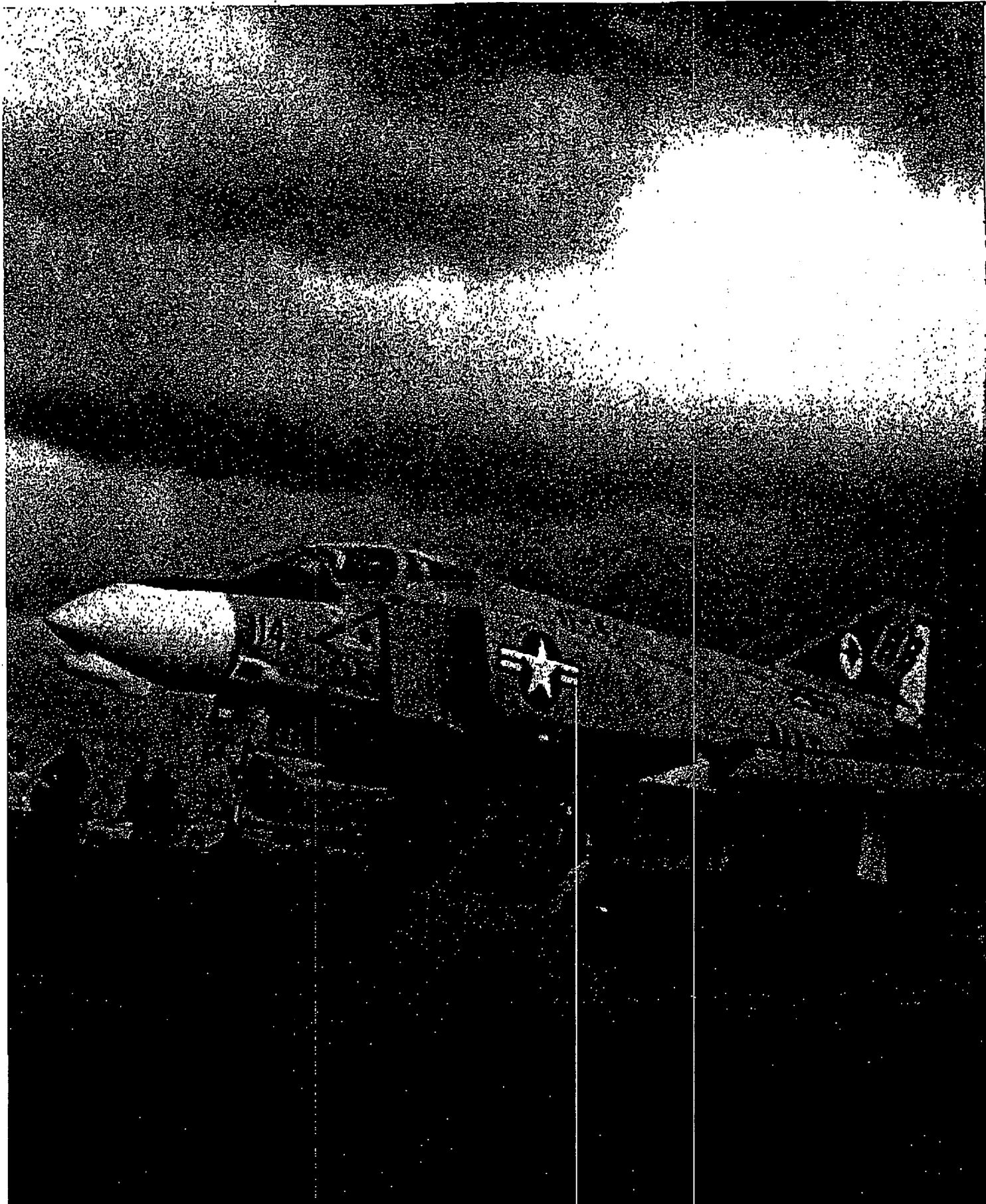




Gulftene Alpha Olefins

	Chemical Name	Structure
Gulftene 4	Butene-1	$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{H} & & \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & \text{H} & & & & \end{array}$
Gulftene 6	Hexene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_3 & & & \end{array}$
Gulftene 8	Octene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_5 & & & \end{array}$
Gulftene 10	Decene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_7 & & & \end{array}$
Gulftene 12	Dodecene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_9 & & & \end{array}$
Gulftene 14	Tetradecene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_{11} & & & \end{array}$
Gulftene 16	Hexadecene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_{13} & & & \end{array}$
Gulftene 18	Octadecene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_{15} & & & \end{array}$
Gulftene 20	Eicosene-1	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_{17} & & & \end{array}$
Gulftene 20-24	Alpha Olefin C ₂₀₋₂₄ Fraction	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_{17-21} & & & \end{array}$
Gulftene 24-28	Alpha Olefin C ₂₄₋₂₈ Fraction	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_{21-25} & & & \end{array}$
Gulftene 30+	Alpha Olefin C ₃₀₊ Fraction	$\begin{array}{ccccccc} & \text{H} & & (\text{H}) & & \text{H} & \text{H} \\ & & & & & & \\ \text{HC} & - & \text{C} & - & \text{C} & = & \text{CH} \\ & & & & & & \\ & \text{H} & & \text{H}_{27+} & & & \end{array}$





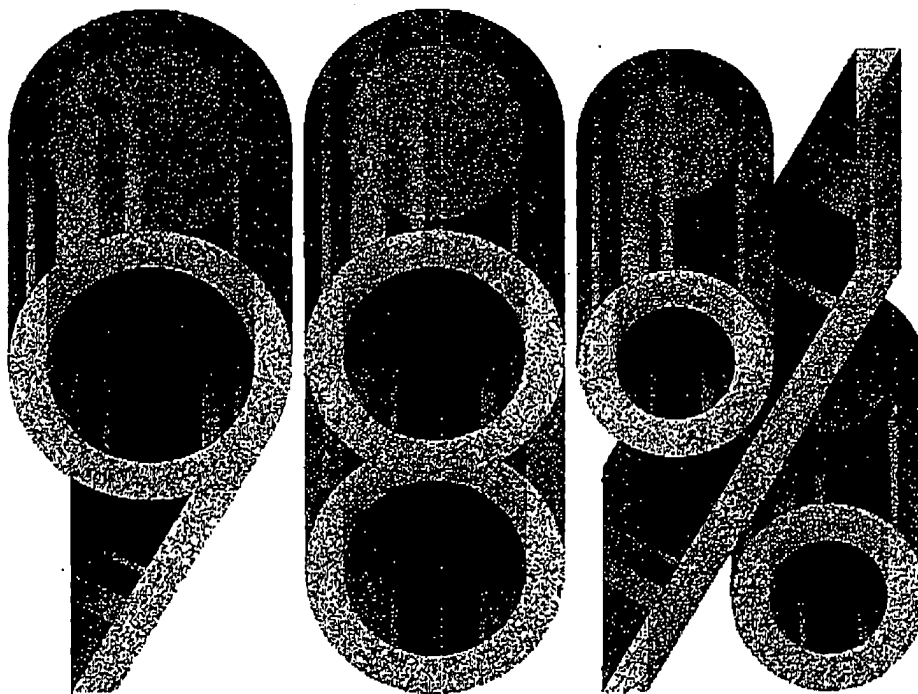
I. Introduction

Gulftene Alpha Olefins

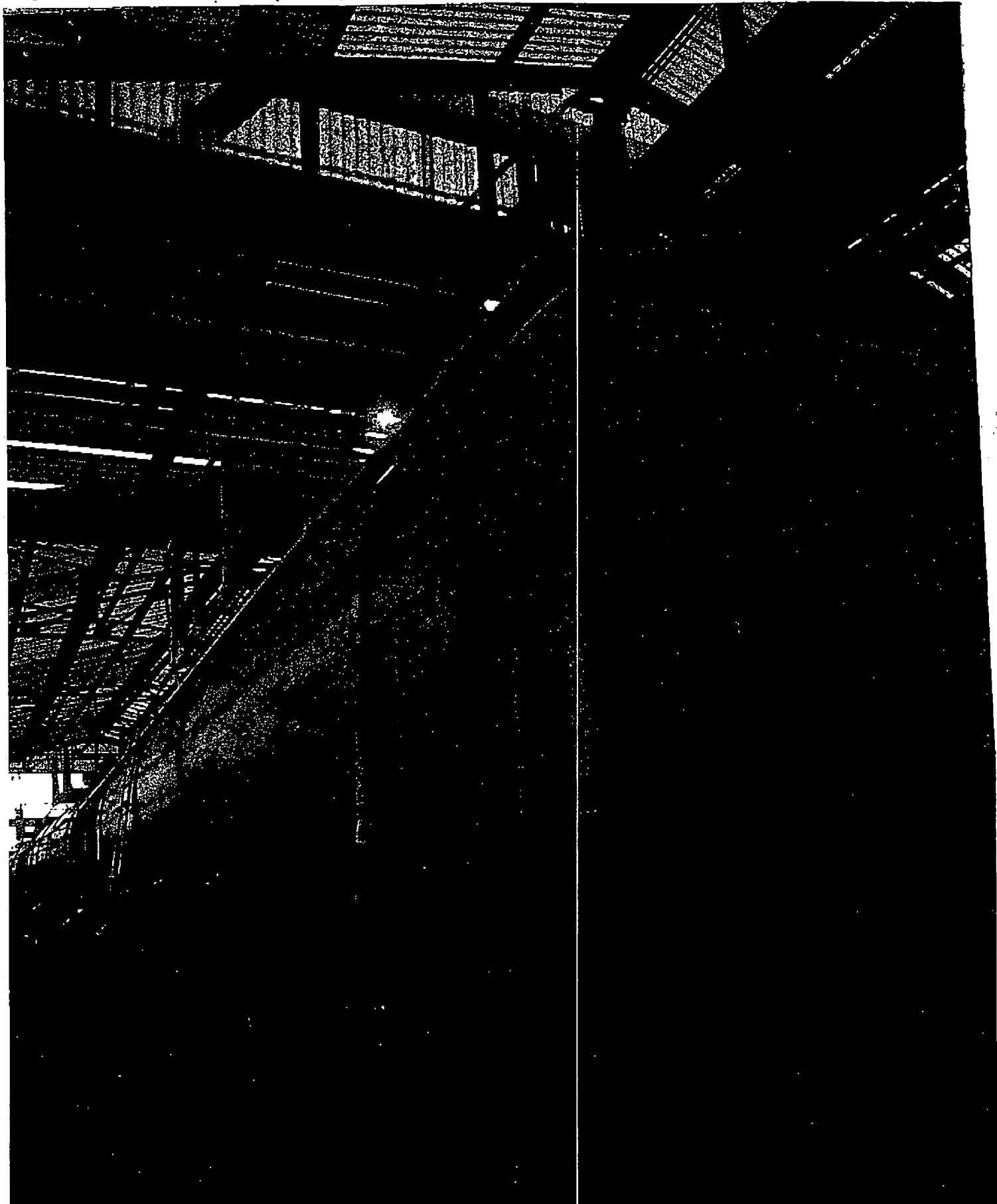
Gulftene is the registered trademark for alpha olefins manufactured by Gulf Oil Chemicals Company by Ziegler polymerization of ethylene. Gulf became the first manufacturer of commercial high-purity alpha olefins in 1966. With individual fractions from C_4 to C_{30} , GOCHEM still has the widest variety of alpha olefins available. Our quality—over 98% monoolefin content of the specified fraction—is to our knowledge not matched by any other producer.

Gulftene alpha olefins are used commercially to produce or upgrade polymers, detergents, lubricants and other consumer and industrial products. The terminal double bond provides a convenient site for conversion of the alpha olefin to intermediates or products of virtually any class of derivative.

Our plant at Cedar Bayou, Texas produces in excess of 120 million pounds of alpha olefins annually.



Flame retardant hydraulic fluids derived from Gulftene alpha olefins are specified for the latest generations of fighting aircraft. U.S. Navy Photo.



II. Gulftene Properties and Shipment

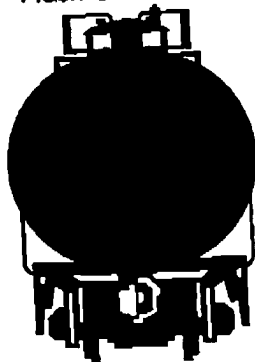
Gulftene Alpha Olefins are clear liquids in the C₆-C₁₈ range with a noticeable olefinic odor. C₄ is a gaseous product and C₂₀+ products are white, waxy solids. All resemble the corresponding paraffin in physical properties.

The even numbered alpha olefins below C₂₀ are available individually and custom blends can be prepared to customer requirements.

The Gulftenes are stored and shipped under nitrogen blanket to prevent peroxidation. Inhibitors such as DuPont 22, Ethyl 733, and Shell Ionol can be added at the rate of 10 pounds, 10 pounds, and 15 pounds per 1,000 barrels, respectively, to inhibit the formation of peroxide in the olefin products. The Cedar Bayou plant ships alpha olefins mostly by tank car and tank truck. However, 55-gallon, steel, epoxy-lined drums and 5-gallon pails are available for a slight additional charge. The Port of Houston is available nearby and export liftings can be made on request.

Table 1. Typical Properties	Carbon Number										
	C ₄	C ₆	C ₈	C ₁₀	C ₁₂	C ₁₄	C ₁₆	C ₁₈	C ₂₀₋₂₄	C ₂₄₋₂₈	C ₃₀₊
Monoolefin, %	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6			
Alpha Olefin, %	98.5	97.0	96.1	95.2	94.0	93.0	92.0	90.8			
Saturates, %	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4		
Flash °F	—	60	60	120	180	225	270	310	375*	380*	510*
P-M	—	—	—	—	—	—	4	18	110	145	180
Melting Point °F	—	—	—	—	—	—	—	—	—	—	—
Specific Gravity 60°/60°F	—	.678	.719	.745	.763	.776	.785	.792	.799	.819	
Distillation 5% °C	—	60	118	164	205	240	270				
95% °C	—	66	128	175	220	255	300				

* Flash COC

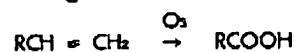


Shipment by tankcar or drum or tank truck may be arranged.

III. Typical Reactions of Gulfenes

Ozonolysis

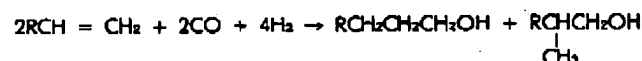
The oxidation of alpha olefins with ozone can be carried out to produce a mixture of acids composed predominantly of an acid one carbon less than the charge olefin.



(Applies to C₁₂+ only)

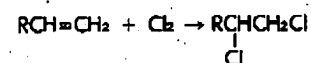
Carboxylation

The Oxo reaction produces a primary alcohol one carbon higher than the chain length of the olefin charge stock. The intermediate stage in the reaction is a mixture of aldehydes. The aldehydes on hydrogenation yield a mixture of isomeric alcohols.



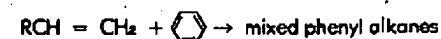
Addition of Halogens

The elemental halogens will add to the double bond of an olefin to yield a dihalide. When chlorine or bromine is used, alpha olefins will usually yield a 1,2-dihalide as the principal product.



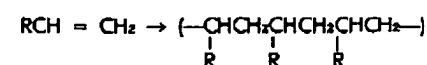
Alkylation with Alpha Olefins

Aromatics are readily alkylated with alpha olefins and the resulting products are useful intermediates for production of surface-active agents. Benzene alkylated with a specific alpha olefin will form a mixture of secondary alkyl benzenes.



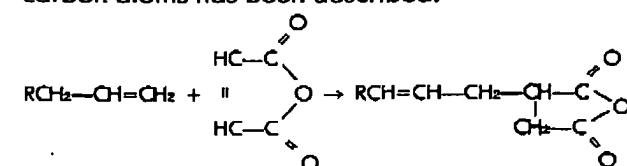
Polymerization

The polymerization of the alpha olefin can be accomplished. Polybutene-1 has been commercialized, and is being used for pipe and film products. Higher alpha olefins can be similarly polymerized to yield unique new polymers.



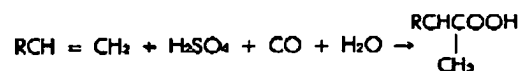
Addition of Maleic Anhydride

The addition of alpha olefins from six to thirty carbon atoms has been described.



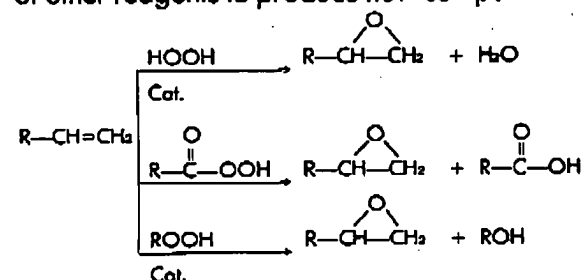
Carboxylation

Olefins can be converted to one carbon higher acids by carboxylation with carbon monoxide.



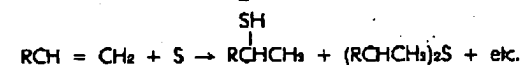
Epoxidation and Hydroxylation

Fairly mild oxidation conditions may be employed to produce long chain epoxides. These epoxides while useful in themselves, may be reacted with a variety of other reagents to produce new compounds.



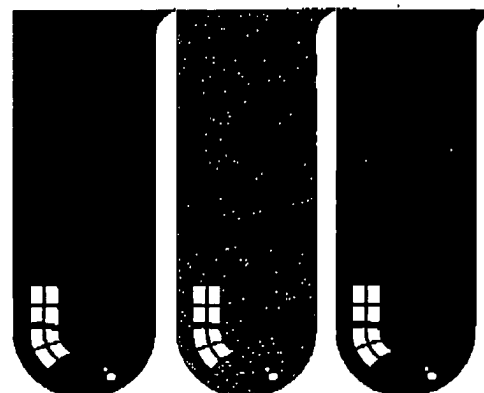
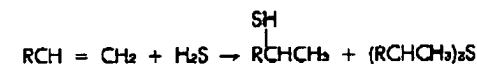
Addition of Sulfur

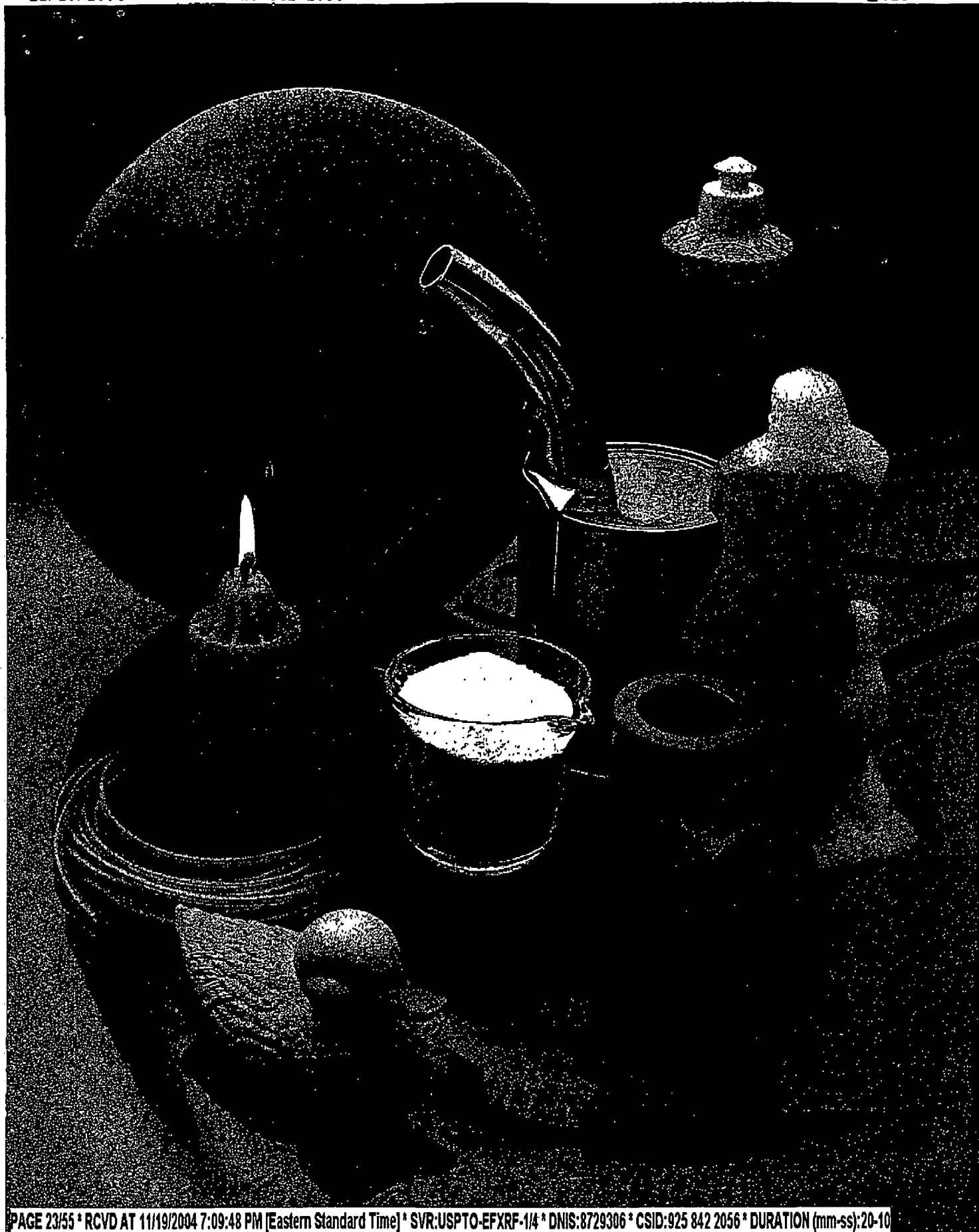
The addition of sulfur to olefins yields a variety of compounds as product including mercaptans, di- and polysulfides. It has been suggested that the sulfur strips hydrogen from unsaturates to form hydrogen sulfide, a part of which adds to more of the unsaturates to give a sulfide.



Addition of Hydrogen Sulfide

The addition of hydrogen sulfide to alpha olefins takes place readily and will follow Markownikoff's rule. Mercaptans and sulfides both are formed. The relative yields of each can be influenced by selection of reaction conditions.





IV. Applications

Gulftene linear alpha olefins produced from Gulf high purity ethylene are low in impurities and adaptive for a wide range of commercial products. The terminal double bond will react readily with a wide variety of chemicals as noted in the previous reaction section.

Primary commercial markets for the reacted Gulftenes are in detergents, lubricants and fluids, and polymers. In each of these market areas several different derivatives of Gulftenes can be produced to fit special requirements. In lubricants, for example, synthetic base fluids can be made from polyalphaolefins, from polyol esters of acids from Gulftenes, or from dialkylbenzene made with Gulftenes. These uses and others are discussed under market applications. Gulftenes can also be used to synthesize almost anything where an even numbered straight carbon chain from C₄ to C₃₀+ is required. When you need a special chemical product with a straight carbon chain as part of the total molecule, it can be made with Gulftenes.

A. Detergents

Gulftenes lead to a diverse variety of detergents. Alpha olefin sulfonates are readily produced with sulfur trioxide using commercial continuous sulfonation units. These sulfonates offer excellent detergency, mildness, rapid biodegradability, compatibility with hard water and good wetting and foaming properties. They make high-quality shampoos, light-duty liquids, bubble baths and heavy-duty liquids and powders.

Alkanesulfonates are readily made from Gulftenes by addition of an alkaline bisulfite under free radical conditions. These products have low solubility which suggest their use in syndet toilet bars.

Gulftenes can be converted to primary alcohols which can then be made into nonionic ethoxylates or anionic ethoxysulfates.

Amines can be prepared from Gulftenes. Various amine derivatives are used commercially for fabric softeners, corrosion inhibitors, biocides and sanitizers.

1. Alpha Olefin Sulfonation

In recent years, the detergent industry has shown increasing interest in alpha olefin sulfonates for surfactant systems. Gulf Oil Chemicals Company has supported this interest with technical service to those companies in the sulfonation and detergent industries, including a sulfonation pilot plant at Gulf's Harnarville, Pennsylvania, Research Laboratories.

Comonomers. Detergents. Vulcanizers. The usefulness of comonomers and sulfonate derivatives of Gulftene alpha olefins extends from C-4 to C-30+.

Many of the results of our work with alpha olefin sulfonation follow with suggested guidelines for preparing alpha olefin sulfonates.

Experience at Gulf Research has shown that alpha olefins can best be sulfonated using continuous, thin-film reactors employing gaseous SO₃. Batch-type equipment, such as the Jergens reactor, does not yield a satisfactory product. Sulfonation reagents such as oleum and chlorosulfonic acid are unsuitable.

In the thin-film sulfonation unit (Figure 1), the alpha olefin and a dilute mixture of SO₃ in air are fed through a specially designed reactor head. Reaction takes place on the reactor wall and the heat of reaction is removed by cooling water in the jacket. Sulfonated olefin liquids are separated from the gas at the bottom of the reactor.

The sulfonated olefins are then neutralized with aqueous sodium hydroxide to produce a solution or slurry of detergent. Optimum neutralization conditions are 350° F, 120 psig, a residence time of 10-20 minutes, and 10 mole % excess of NaOH. The product will have a pH of about 11-12. The alpha olefin sulfonate can be stored at a pH of about 10, but is adjusted to a pH of 7.5-8 before final use.

Optimum reaction conditions are somewhat dependent upon the carbon number of the alpha olefin. The following conditions should produce an alpha olefin sulfonate, in the C₁₄-C₁₆-C₁₈ carbon range, with a Klett color below 100 (without bleaching) and a neutral oil content below 2%.

Unit Operating Conditions

SO ₃ /olefin molar ratio	1.03-1.07
Air rate/sq. in. of reactor cross section, SCFM	50-60
Cooling water temperature	0-35° C
Olefin feed rate, lb/hr (for 1"x22' reactor)	40-50



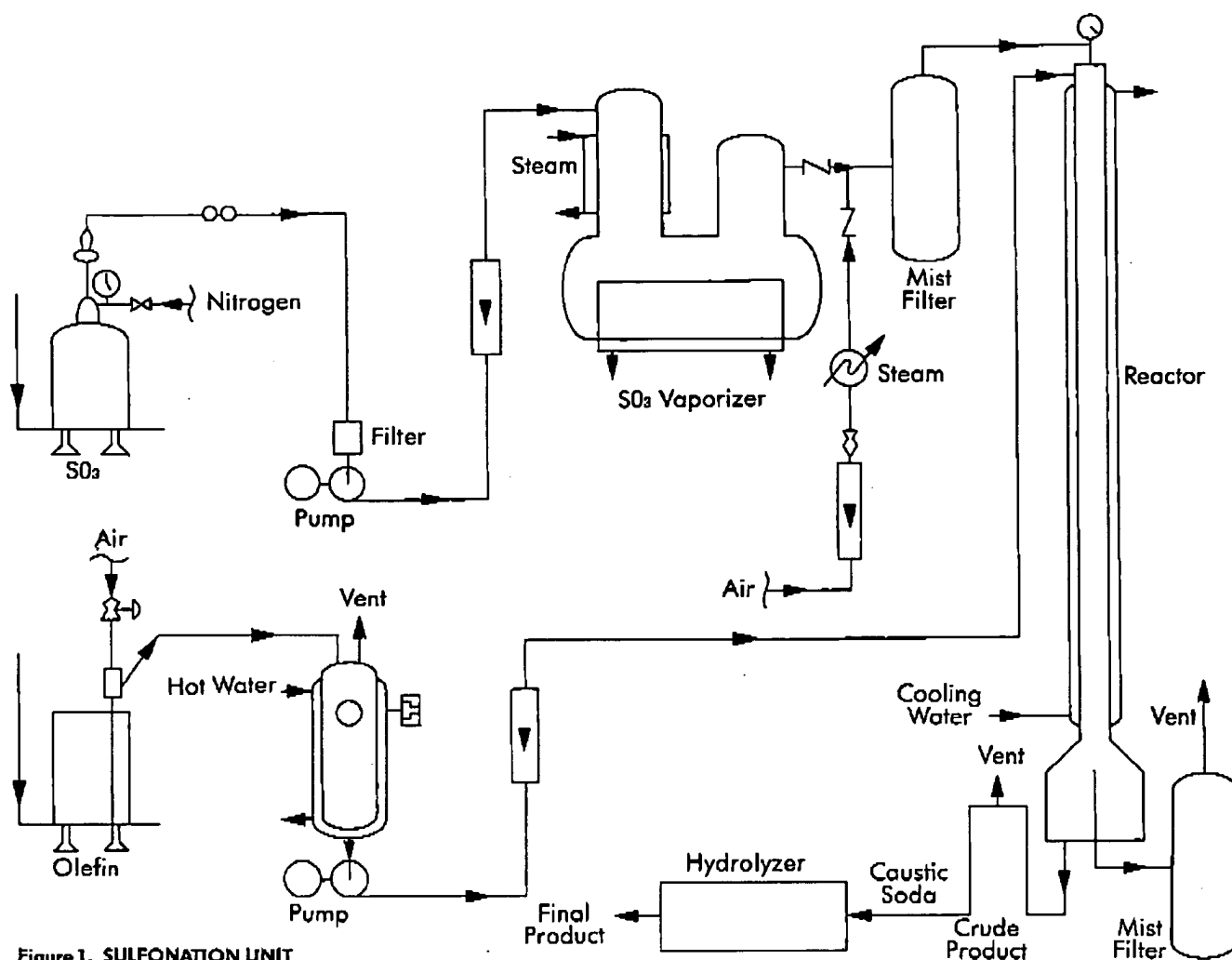


Figure 1. SULFONATION UNIT

2. Alpha Olefin Sulfonates

Alpha olefin sulfonates have properties not found in other detergents. Their ease of biological degradation exceeds the rates obtained with linear alkylate sulfonates (Figure 2). Solubility is good and better than that of n-alkyl sulfates and alkanesulfonates. The viscosity of aqueous mixtures at moderate concentrations is low, which permits ease in processing and handling. Resistance to precipitation by water hardness and other metallic ions is very good and superior to alkanesulfonates. Detergency of cotton is comparable to the best commercial alkylbenzene sulfonates and definitely superior to the lower molecular weight dodecylbenzene sulfonates (Figures 3

and 4). Since the detergency of alpha olefin sulfonates is dependent on the average carbon number of a blend rather than on its particular make-up, the composition can be altered to achieve desired overall performance characteristics. Blends containing sulfonates from alpha hexadecene to alpha eicosene lend high detergency to heavy-duty products. Foaming ability (Figures 5 and 6) is excellent and comparable to alcohol ethoxy sulfates. Alpha tetradecene and alpha hexadecene sulfonates are applicable for light-duty products and show excellent foam stability in hand dishwashing (Figures 7, 8 and 9).

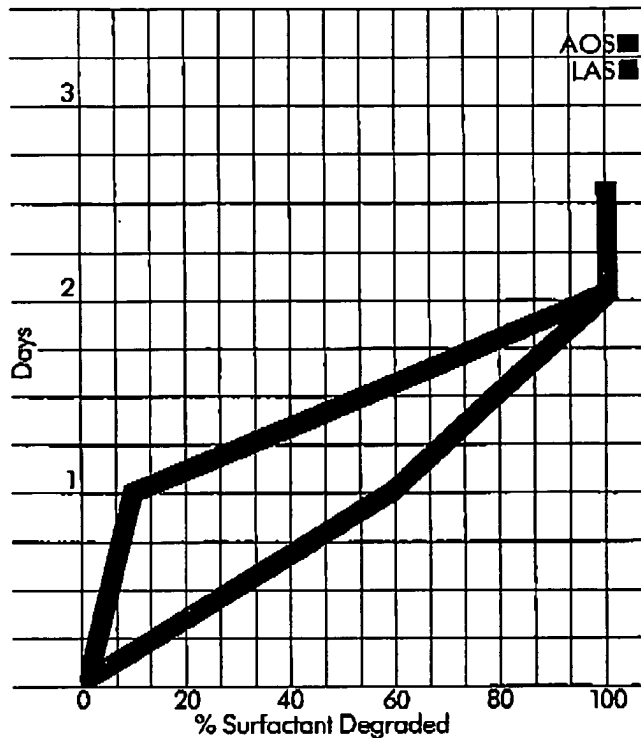


Figure 2. BIOLOGICAL DEGRADATION BY THE SHAKE FLASK CULTURE TECHNIQUE

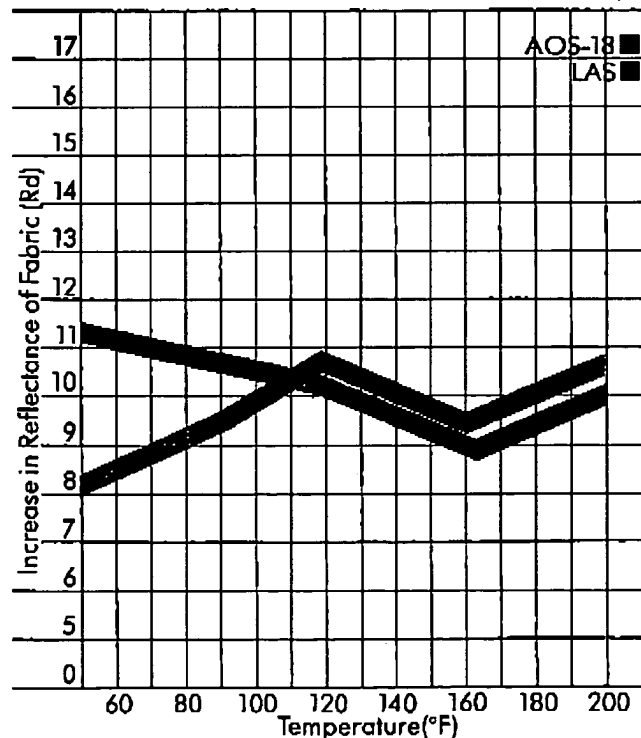


Figure 3. DETERGENCY OF COTTON

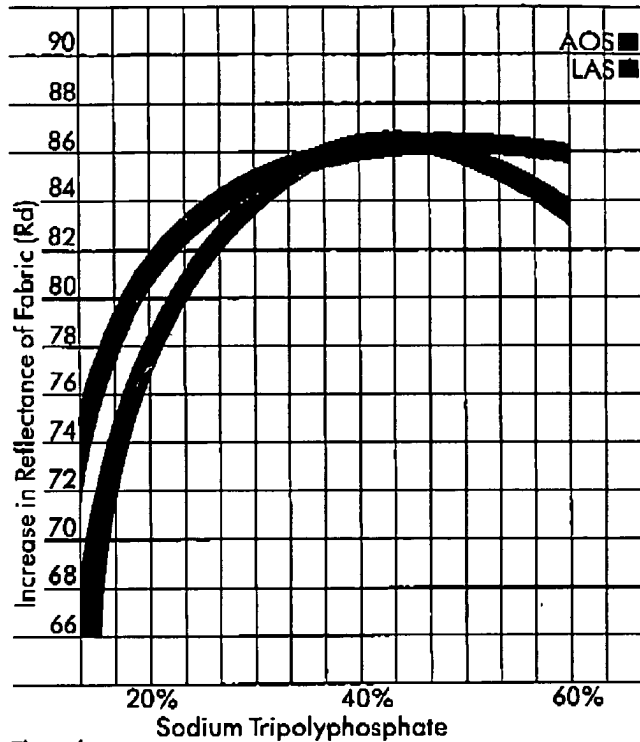


Figure 4. DETERGENCY OF COTTON

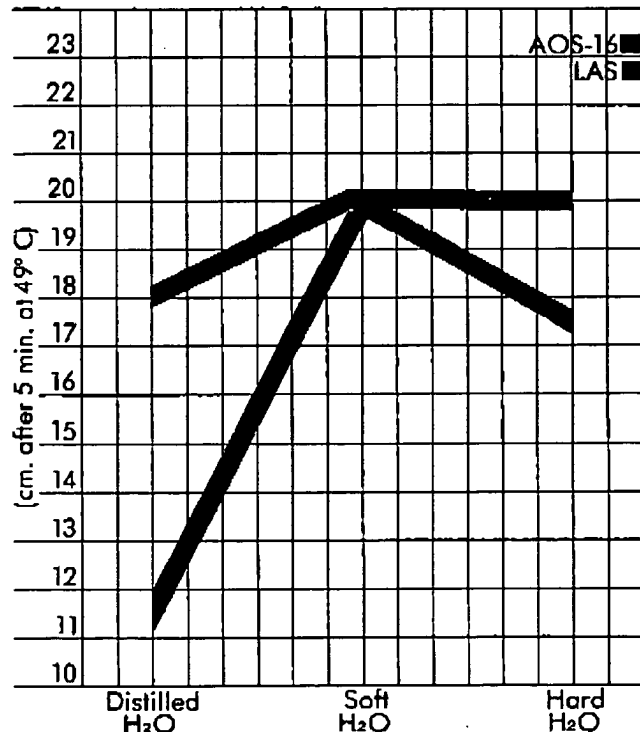


Figure 5. FOAMING ABILITY (0.05% Concentration)

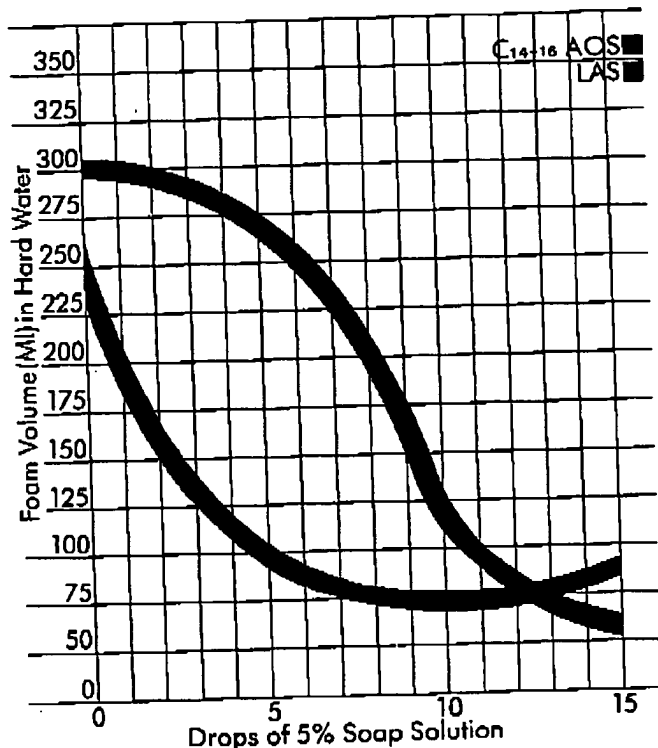


Figure 6.
FOAMABILITY IN PRESENCE OF SOAP

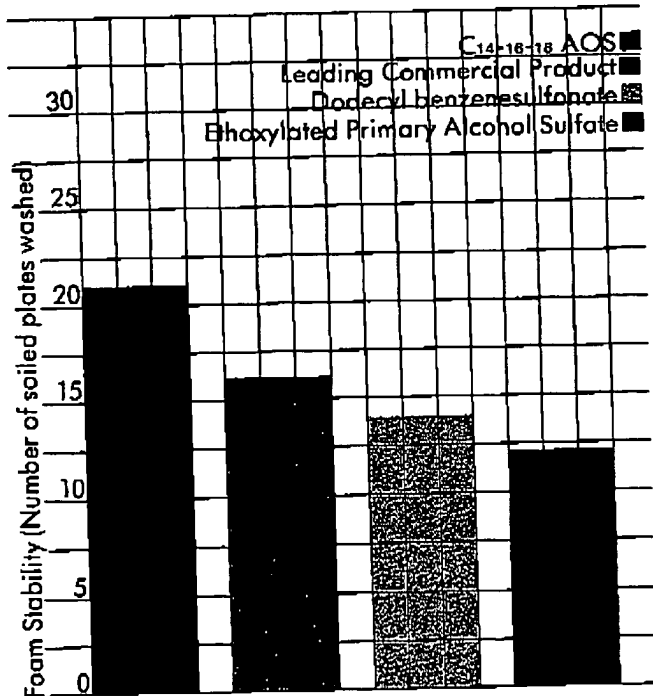


Figure 7.
MAINTAINING FOAM PERFORMANCE

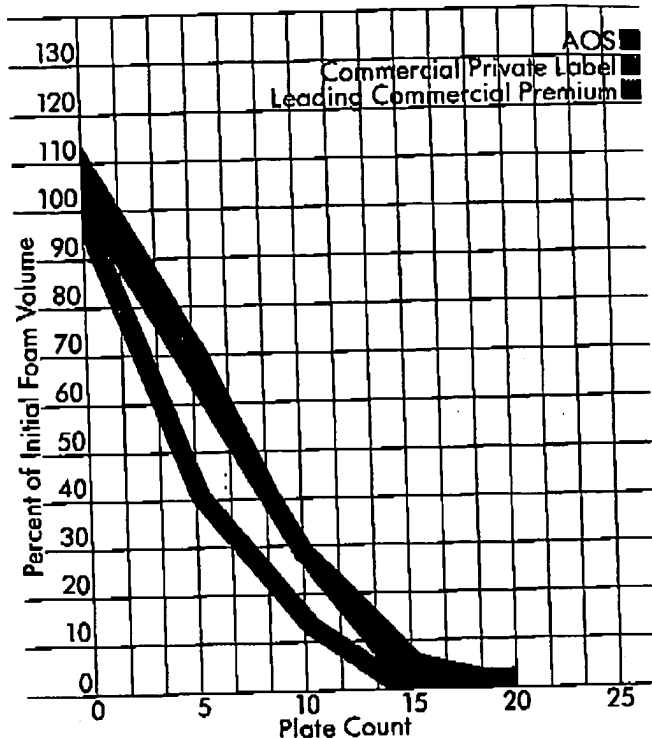


Figure 8.
FOAM STABILITY BY DISHWASHING

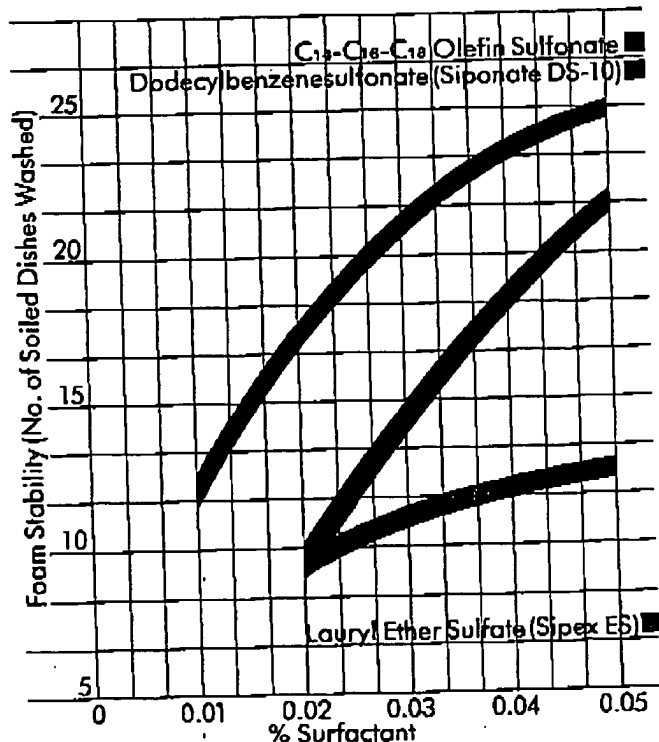


Figure 9. EFFECT OF CONCENTRATION ON PERFORMANCE OF SURFACTANTS

3. Shampoos

Gulftene alpha olefins may be converted to sulfonates for use in shampoos. Investigation of alpha olefin sulfonates by Gulf Research personnel shows that C₁₄ and C₁₄₋₁₆ alpha olefin sulfonate blends perform particularly well.

In three critical areas of shampoo performance, these alpha olefin sulfonates perform as well as or better than conventional shampoo surfactant systems.

Foaming ability

The foaming ability of C₁₄ and C₁₄₋₁₆ alpha olefin sulfonates in the presence of synthetic hair oil is equal to that of lauryl sulfate and lauryl ethoxy (1) sulfate and superior to lauryl ethoxy (3) sulfate and linear alkylbenzene sulfonate (LAS). In the presence of synthetic body oils (sebum), C₁₄ and C₁₄₋₁₆ alpha olefin sulfonates are comparable in foaming ability to lauryl sulfate and lauryl ethoxy (3) sulfate and superior to LAS.

Foam stability

C₁₄ and C₁₄₋₁₆ alpha olefin sulfonates perform about as well as or slightly better than lauryl sulfate. Higher olefin sulfonates, such as C₁₆ and C₁₈, do not maintain foam as well as lauryl sulfate.

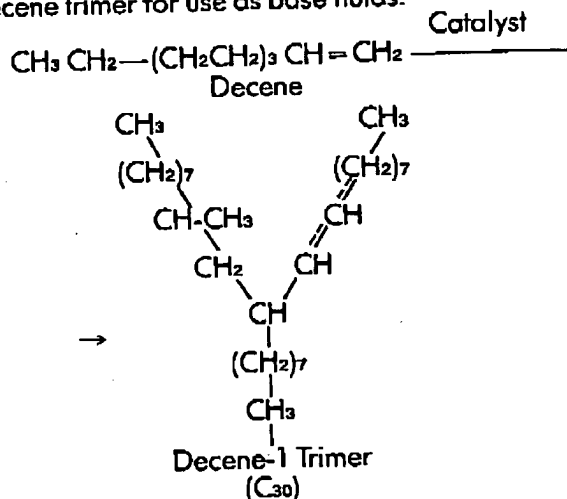
Hard water tolerance

Another important advantage of alpha olefin sulfonates in shampoo formulations is their resistance to precipitation by hard water. Olefin sulfonates in the C₁₄ and C₁₄₋₁₆ range show a distinct advantage over lauryl sulfate in tolerance to very hard water.

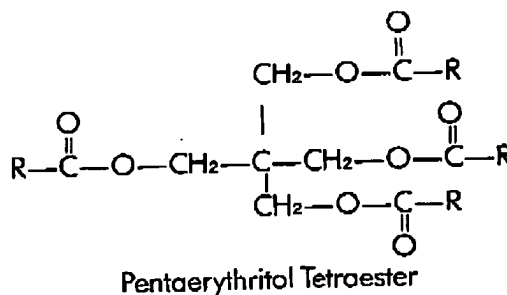
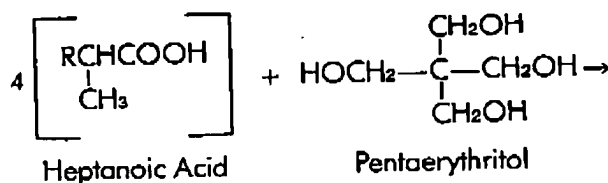
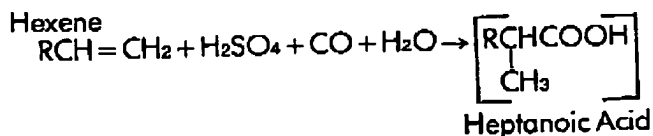
Sulfonates derived from Gulftene alpha olefins have excellent solubility. Neutralization of the olefin sulfonate with caustic soda produces a product more soluble than sodium lauryl sulfate, and in the latter case resort is made to the more expensive alkanolamine salts to achieve adequate solubility. For example, the cloud points of C₁₄ and C₁₄₋₁₆ olefin sulfonate solutions are -5° and 0° C, respectively. Cloud points of the sodium salts of lauryl sulfate are typically higher than for alpha olefin sulfonates, and may be decreased only by the use of more expensive triethanolamine salts.

B. Synthetic Lubricants and Functional Fluids

Synthetic base fluids for lubricating oils can be prepared by catalyzed oligomerization of Gulftene alpha olefins. Decene in particular is polymerized to decene trimer for use as base fluids.

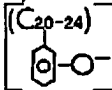


Gulftene alpha olefins yield odd-numbered acids upon carboxylation. Polyol esters are then prepared by reacting acids with polyols such as pentaerythritol.



The esters are used as additives to other lubricants or as base fluid for synthetics. They offer wide temperature tolerance similar to the oligomerized alpha olefins.

Phenol or benzene can be alkylated with Gulfene alpha olefins. Alkylbenzene sulfonates are excellent detergents as additives in lubricating oils. Dialkylbenzene (C_{10} or 12) [9] C_{10} or 12) has useful properties as a synthetic fluid and lubricant. Phenate (alkyl phenol) [C_{20-24}]



$[O-O]_2Ca^{++}$ is another derivative used for lube additives. Chlorinated alpha olefins are very stable and useful as extreme pressure additives in metal working fluids.

1. Polyalphaolefin lubricants and synthetic fluids

The polyalphaolefin fluids, for example Synfluid® produced by GOCHEM, are used as base fluids for compounding with additives to form high performance lubricants. Polyalphaolefins offer advantages of:

1. Good low temperature viscosity (Figure 10)
2. Long service life and better stability (Figure 11)
3. High inherent viscosity index
4. Low volatility
5. Compatibility with natural oils and other synthetic base fluids

These advantages can confer superior properties to engine lubricants and hydraulic fluids used in aviation, automotive and industrial applications.

2. Alkylation with Gulf Alpha Olefins

2. Alkylation with Gull Alpha Olefins
Gulfene alpha olefins have been successfully employed in the alkylation of various aromatic species. Alpha olefin alkylates of benzene and phenol have been prepared and evaluated.

Alkylation of aromatics with any of the Gulf alpha olefins is basically a Lewis-acid-catalyzed, Friedel-Crafts reaction. Aluminum trichloride is the preferred acid for benzene alkylation, although higher yields have been obtained with anhydrous hydrofluoric acid. Alkylation of phenol with alpha olefins seems to proceed best when boron trifluoride is used. Anhydrous HF has been reported in naphthalene alkylations.

Bench scale preparations of alpha olefin alkylate have been performed at Gulf's research labs. Typical preparations are:

Benzene Alkylation

Benzene alkylation with octene-1 was performed in standard laboratory glassware using commercially available octene-1. The benzene was dried to a

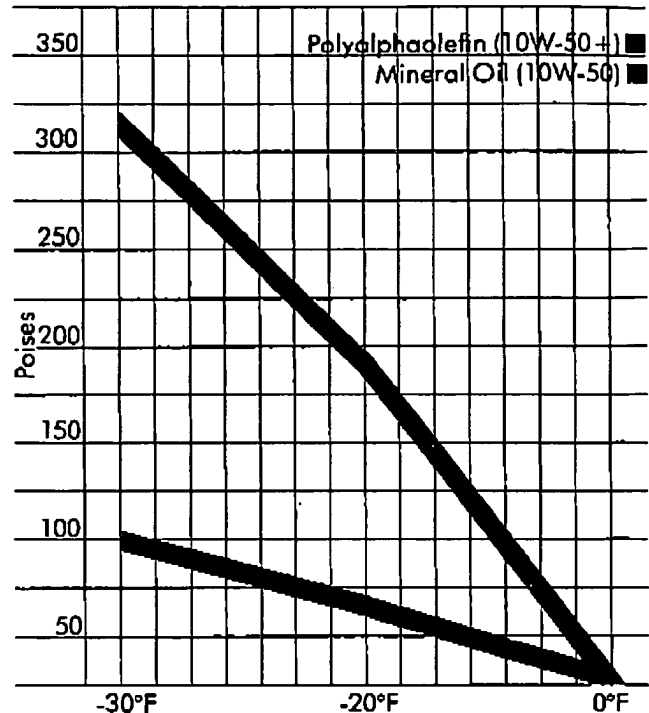


Figure 10.
LOW TEMPERATURE VISCOSITY

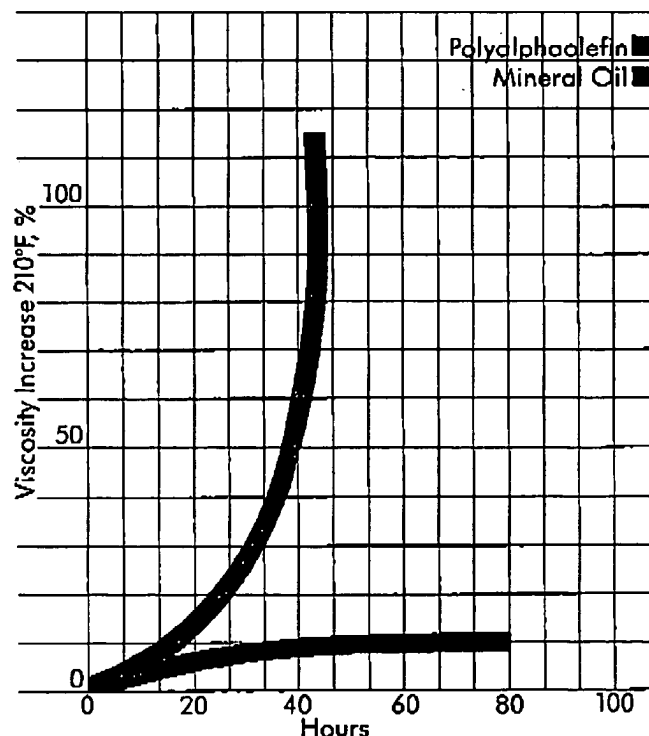


Figure 11.
TEMPERATURE STABILITY

moisture content of 65 ppm by azeotropic distillation. Typically, one part of olefin was added, over 45 minutes, to a stirred mixture of 6.5 parts of benzene containing 0.6% of anhydrous aluminum chloride based on the weight of reactants. The temperature was approximately 45°C. After completion of olefin addition, stirring was continued for five minutes. The reaction products were decanted from the solid catalyst residue after a 15 minute settling period. The reaction products were washed with either dilute caustic or hydrochloric acid followed by water. The water was analyzed by gas chromatography. The alkylate was recovered by fractionation distillation at 60 mm Hg pressure.

Phenol Alkylation

The following preparation of a C₁₀ alpha olefin alkylphenol is generally applicable to lower molecular weight alpha olefins. Some modification in reaction conditions is necessary for alkylation employing higher molecular weight alpha olefins.

A phenol/alpha olefin ratio of 2/1, mol/mol was employed in order to inhibit the formation of dialkylate. Figure 12 indicates the effect of reactant ratio on product composition. The 2/1 molar ratio results in a product which is 76% monoalkylate, 23% dialkylate and 1% trialkylate. The use of higher phenol/olefin ratios will result in an increased percentage of monoalkylate. However, higher monoalkylate concentration must be balanced against energy expended in phenol separation and in the cost of discarded quantities of phenol.

Aromatics alkylated with Gulf alpha olefins have numerous applications in the chemical and allied industries. Alkylation of benzene with detergent range alpha olefins yields linear alkylate for detergent applications. The primary use of these products will be as detergent intermediates sulfonated to surface active agents.

Alkylation of phenols with Gulf alpha olefins yields products with numerous commercial applications including antioxidants, lube oil additives, plasticizers, and surface active agents. In the area of surface active agents, ethoxylation of phenols alkylated with higher molecular weight Gulf alpha olefins is of particular promise. A separate Gulf product application bulletin describes in detail the surfactant properties of ethoxylated linear alkyl phenols.

C. Polymers

Gulftene C₄, C₆ and C₈ alpha olefins are useful to form improved high density polyethylene homopolymers. Gulf butene, hexene and octene are very high-purity products and free of catalyst poisons.

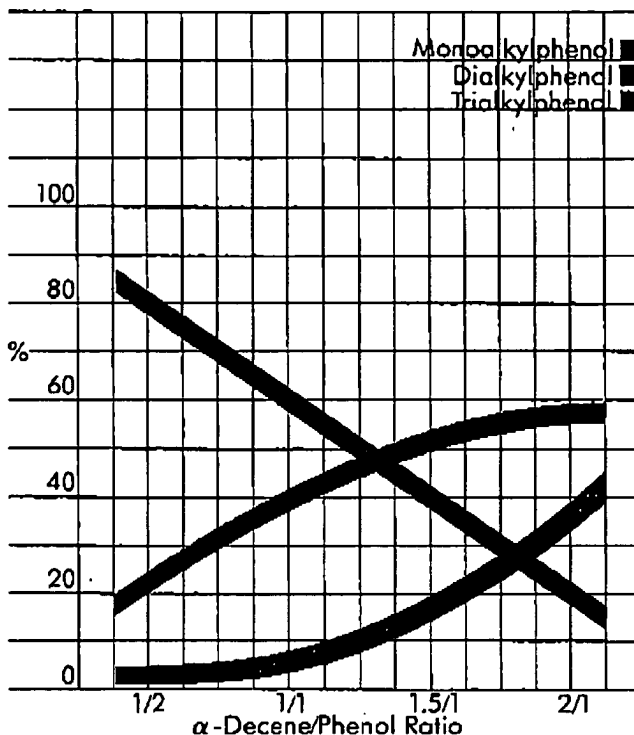
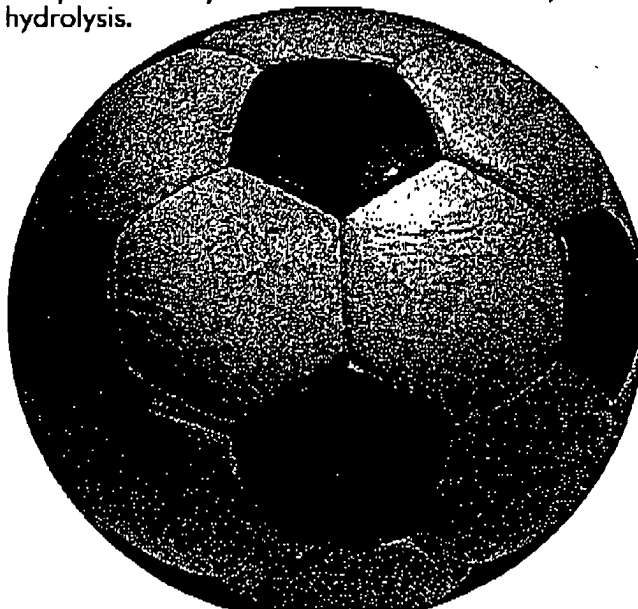


Figure 12.
EFFECT OF REACTANT RATIO ON PRODUCT COMPOSITION
IN THE DIALKYLATION OF PHENOL WITH α-DECENE

Linear alcohols are readily formed from these Gulftene alpha olefins (C₆, C₈, C₁₀) and can be made into superior linear phthalate esters for plasticizers. The alcohols can be formed by the oxo process or hydrobromination followed by hydrolysis.



Gulftene 4 can be polymerized to polybutene. Polybutene has several properties that make it ideally suited for many engineering applications. Among the most outstanding are its long-term mechanical properties. Creep resistance is excellent for a semi-crystalline polyolefin; in fact, PB behaves more like a crosslinked plastic. And in addition, PB shows no signs of cracking, crazing or fracturing when stressed below its short-time failure stress value for long periods of time. It exhibits a unique combination of good tensile and tear properties. The tensile breaking strength is very high for a polyolefin, and its tear strength depends greatly upon tear rate, increasing rapidly with increased tear rate.

Polybutene is less sensitive to commonly known surface cracking chemicals, such as environmental stress-cracking agents. It needs protection, however, from ultraviolet light and certain corrosion agents that commonly degrade polyolefins. Ultraviolet light stability can be improved with screening agents and stabilizers.

Gulftene 20-24 can be chlorinated for use as a secondary plasticizer where it contributes to flame retardation. Alpha olefins chlorinate more readily than paraffins due to the double bond.

Gulftene 6, 8 and 10 (C_6 , C_8 , C_{10}) have been co- and terpolymerized with vinyl acetate and vinyl chloride.

Gulftenes can be used as a copolymer with acrylonitrile to form a polymer with interesting properties.

Copolymers of maleic acid and Gulftene's 4 through 18 (C_4 - C_{18}) can be formed using peroxides as catalysts. The products are resins of interest for paper sizing, sheet molding compounds, etc.

1. Polyethylene Copolymers

High density polyethylene homopolymers are known to be deficient in their ability to resist environmental stress-cracking (ESCR). Although this problem may be minimized by producing a polymer with a low melt index (high melt viscosity), copolymerization using Gulftene-6 (hexene-1) offers a unique solution. In many polymer applications, such as blow molding, high flow rates are called for, and a material with a low melt index becomes a liability. Addition of Gulf hexene-1 as a comonomer will allow a polymer to be formed that exhibits very good flow properties while retaining a low melt index. In addition, the ESCR of the material is greatly increased.

Gulftene-6 has been found to be superior in improving the ESCR of particle form polymers. Gulftene-8 (octene-1) alpha olefin can also be used in this application and is as effective as Gulftene-6 in increasing the ESCR of the polymer. However, to achieve higher polymer densities, a higher concentration of Gulftene-8 is required.

Comparative tests using the Gulf Ziegler-derived Gulftene-6 and a hexene-1 obtained via wax-cracking point out the advantages of the high-purity Gulf material. In two different runs, each using identical amounts of each olefin, the productivity (pound of polymer formed per pound of C_6 used) of the Gulftene-6 was over twice that of the wax-cracked olefin. The Gulf material was determined to be free of catalyst poisons, and the finished polymer showed better incorporation of comonomer.

Gulftene-6 comonomer can be used under the same reaction conditions as Gulftene-4. Catalyst productivity and reaction temperature/melt index relationships are unchanged. However, ESCR is substantially increased with Gulftene-6 versus Gulftene-4. For example, at a polymer density of 0.95 and melt index ranges of 0.20 to 0.30, Butene-1

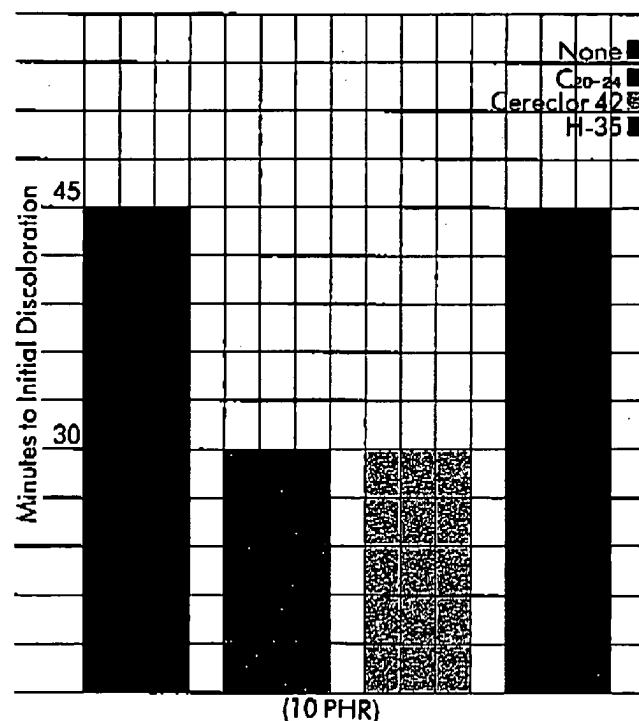


Figure 13.
OVEN HEAT STABILITY

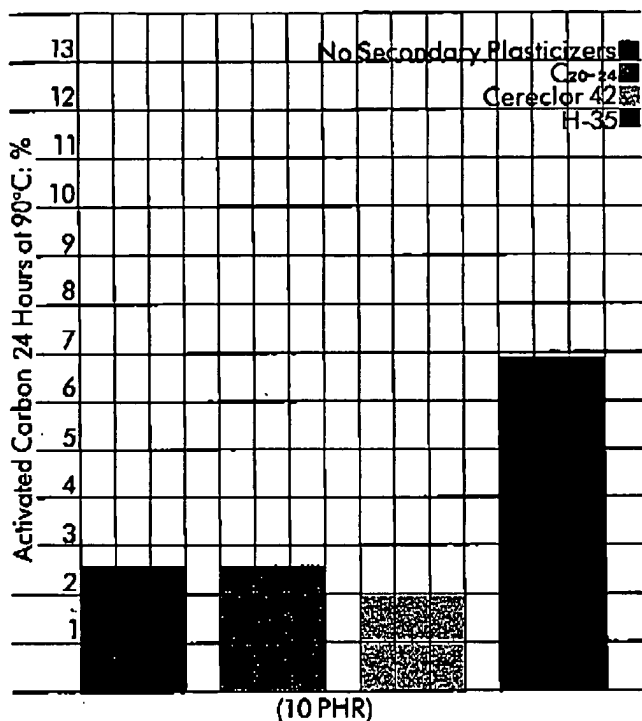


Figure 14. VOLATILITY COMPARISON OF CHLORINATED C₂₀₋₂₄ WITH OTHER COMMERCIAL SECONDARY PLASTICIZERS

copolymers had ESCR values of from 50 to 310 hours. Hexene-1 exhibited Bell ESCR values of from 800 to more than 1,000 hours under the same conditions. Overall, Hexene-1 will improve polymer ESCR values without sacrificing polymer yield processability, or other polymer properties.

2. Chlorinated Alpha Olefins

Gulf Oil Chemicals Company has evaluated a 40% chlorinated Gulftene 20-24 (C₂₀₋₂₄ alpha olefin) as a secondary plasticizer in PVC formulations. This alpha olefin derivative was evaluated in comparison with ICI's Cereclor 42 (42% chlorinated paraffin) and Conoco's H-35 (alkyl-aryl hydrocarbon).

The evaluation of the mechanical properties of the formulations show that the chlorinated Gulftene alpha olefin is equivalent in plasticizing efficiency to the two other secondary plasticizers evaluated. The results are shown in Figures 13 and 14. In heat stability, the chlorinated Gulftene 20-24 is similar to Cereclor 42 and not quite as good as H-35. The volatility of chlorinated Gulftene 20-24 is better than that of H-35 but slightly poorer than Cereclor 42 (Figure 14).

The evaluation indicates that the 40% chlorinated C₂₀₋₂₄ alpha olefin is an acceptable secondary plasticizer for PVC.

D. Miscellaneous Applications

Mercaptans can be formed by the addition of hydrogen sulfide to alpha olefins under proper conditions. These mercaptans are useful for rubber additives and specialty chemicals.

Alkenylsuccinic anhydrides can be prepared by heating alpha olefins (C₁₀₋₂₀) and maleic anhydride above 190°C. These products are useful in paper sizing and starch products.

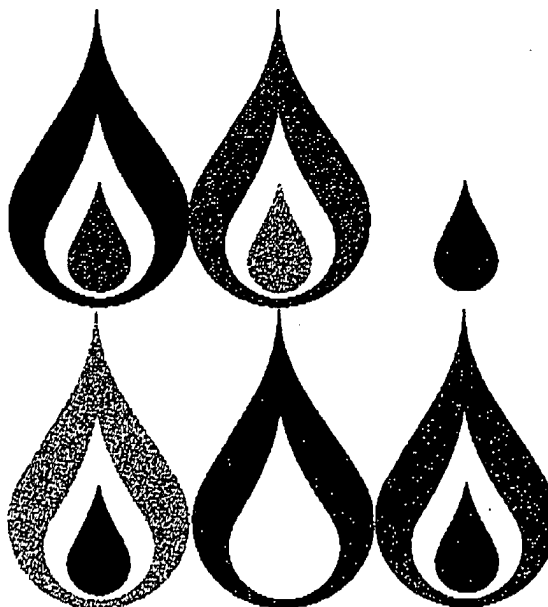
Maleic anhydride may be added to alpha olefins forming copolymers. Laboratory and commercial testing indicate these resins are:

1. effective curing agents for epoxy resins
2. unique thermoset resin compositions in liquid monoepoxides
3. interesting as simple salts for textile sizes and protective colloids
4. excellent leveling resins (as half ester derivatives) in floor polish formulations.

The alpha olefins above C₂₀ are waxy products and can find uses similar to paraffins. For example, C₃₀₊ improves wax blends for candles, crayons, and coatings. These fractions may also be further reacted to simulate more expensive carnauba or Montan waxes.

Alpha olefins may be converted by metathesis or disproportionation and dimerization reactions to olefins of different chain lengths.

Ketones and esters may be made from alpha olefins. Pyrazines have also been made from alpha olefins.





V. Toxicology

Names

The compounds discussed in this brochure are named according to carbon chain length where specific entities are involved. The compounds are:

- C₆ Alpha Olefin (hexene-1) Gulftene-6
- C₁₀ Alpha Olefin (decene-1) Gulftene-10
- C₁₆ Alpha Olefin (hexadecene-1) Gulftene-16
- C₁₂₋₁₆ Alpha Olefin Blend

The Gulftene Alpha Olefins chosen above for this toxicological study are considered representative of the product line, allowing for reasonable interpolation with specific blends or compounds not included.

Physical Properties

Table 2.

	C ₆	C ₁₀	C ₁₆	C ₁₂₋₁₆
Physical State	Liquid	Liquid	Liquid	Liquid
Molecular Weight	84	140	224	178
Boiling Point: °F	147	338	539	401-572
Flash Point (TOC) °F	<20	128	>200	195
Vapor Pressure mm Hg @ 75°F	176	1.6	<1	<1

Toxicity

Threshold Limit Values: None established by ACGIH*

Gulf suggested Threshold Limit Value:

Vapors— 500 ppm (parts per million by volume) by analogy with saturated aliphatic hydrocarbons. Higher molecular weight materials should fall short of this concentration due to their lower vapor pressure.

Mists— 5 mg/m³ by analogy with mineral oil mists.

Animal Toxicity Data: (See Table 3) Animal studies have shown the alpha olefins to have little or no toxic effect except under very severe inhalation conditions. The oral and dermal LD50 values for the tested alpha olefins are in excess of 10gm/kg (non-toxic**); skin and eye irritation are minimal, at most; sensitization has not been demonstrated. Inhalation anesthetic effects were produced when the C₆ olefin vapor concentration approached the LC50 of 32,000 ppm. Light anesthetic effects

*American Conference of Governmental Industrial Hygienists

**Federal Hazardous Substance Act

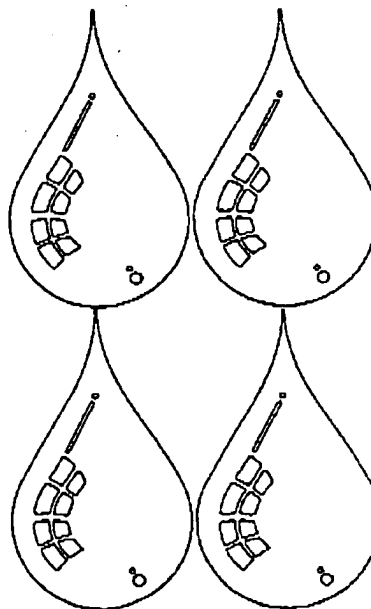
occurred with separate exposures to air saturated with C₁₀ olefin vapors, C₁₆ and C₁₂₋₁₆ olefin mists.

Industrial exposures to very high vapor concentrations of the C₆ olefin such as might be produced in an enclosed, unventilated space may induce loss of consciousness or death if exposure is prolonged. Exposure for prolonged period at levels above the suggested Threshold Limit Value for the other olefins might produce giddiness or incoordination similar to that anticipated for the saturated aliphatic hydrocarbons.

Handling and Personnel Protection

Excessive and prolonged exposures to vapors should be prevented. Local or general exhaust ventilation should be used to prevent accumulation of high vapor concentrations above the recommended TLV. Where adequate engineering controls are not available, a NIOSH certified organic vapor respirator or supplied air breathing apparatus should be used. Vapor concentrations expected to be harmful to health may also constitute a hazard from fire or explosion.

As a matter of good industrial hygiene practice, avoid splashes of the liquid in the eyes or prolonged contamination of the skin. Splashes in the eye should be removed by thorough flushing with water and skin areas should be washed with soap and water. Contaminated clothing should be laundered before reuse.



Animal toxicity data appears on card

Animal Toxicity Data

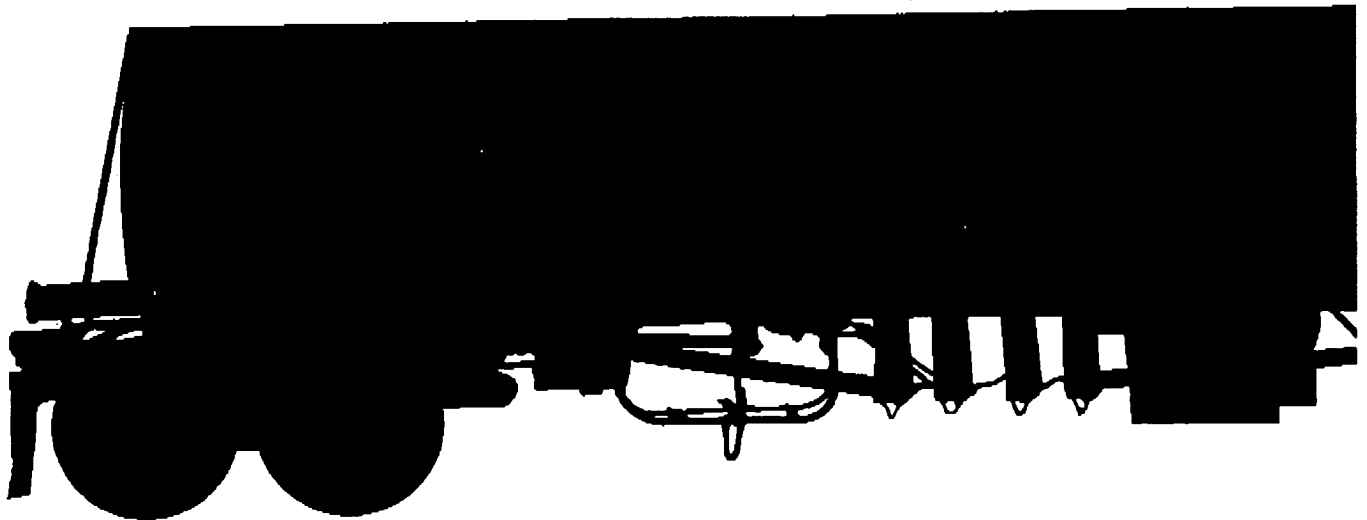
Table 3.

Study Description		C ₆	C ₁₀
Acute Oral— Rats, LD50 Values Given		>10 gm/kg	>10gm/kg
Acute Dermal— Rabbits, LD50 Values Given		>10 gm/kg	>10 gm/kg
Dermal Irritation— Rabbits, Draize Score Given		1.0	0.9
Eye Irritation— Rabbits, Draize Score Given	24 hr:	1.7	0.7
	48 hr:	1.3	0.3
	72 hr:	0.7	0.0
Inhalation— Rats, Saturated Concentrations & Results Given		Vapor Exposure: 5 min. @ 161,000 ppm Mortality: 10/10 Clinical Signs: Tremor, convulsions, death. Some evi- dence of pulmonary irritation.	Vapor Exposure: 1 hr. @ 320 ppm Mortality: 0/10 Clinical Signs: Sleepy, dazed during exposure. Rapid recov- ery after exposure.
Inhalation— Rats, 4 Hr. Vapor Exposures & Mortality Given		27,600 ppm-0/10 28,600 ppm-2/10 30,500 ppm-5/10 33,200 ppm-7/10 37,000 ppm-8/10 41,200 ppm-10/10 Calculated LC50 (4 hr.)— 32,000 ppm (95% confidence interval of 30,000-34,200 ppm)	
Skin Sensitization— Guinea Pigs. Testing Procedure—Landsteiner Variation. Results Given			

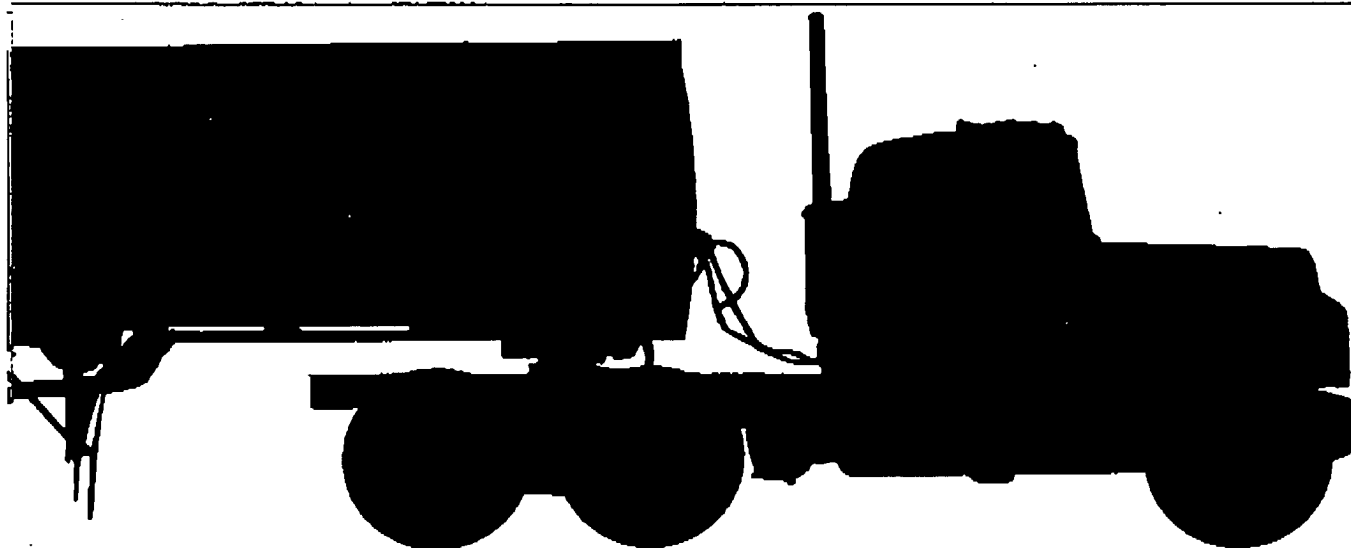
C ₁₆	C ₁₂₋₁₆ Blend	Comments
>10 gm/kg	>10 gm/kg	Transient weight loss after dosing. Not-toxic (FHSA)
>10 gm/kg	>10 gm/kg	No regrowth of hair. Skin dry & scaly for 2 wks. after dosing. Not-toxic (FHSA)
0.6	0.4	Very mild to slight irritation. Not "primary irritants" by FHSA definition.
1.3 0.3 0.0	1.0 0.7 1.3	Transient, slight to mild conjunctival redness, no cornea or iris impairment. Non-irritating by FHSA definitions.
Mist Exposure: 1 hr. @ 8,500 mg/m ³	Mist Exposure: 1 hr. @ 9,900 mg/m ³	Most severe possible conditions for vapor & mist exposure.
Particle Size: <8 microns in diameter.	Particle Size: <8 microns in diameter.	
Clinical Signs: Drowsy, no deaths.	Clinical Signs: Drowsy, no deaths.	
		Progressive light to severe anesthetic effects. All deaths occurred during exposure. Recovery rapid on removal from vapors.
	Test—negative response to challenge application.	Not a dermal sensitizer. No anticipated dermal sensitization to alpha olefins.
	Control (chlorodinitrobenzene)— positive response to challenge application.	
	Control (vehicle)—negative response to challenge application.	

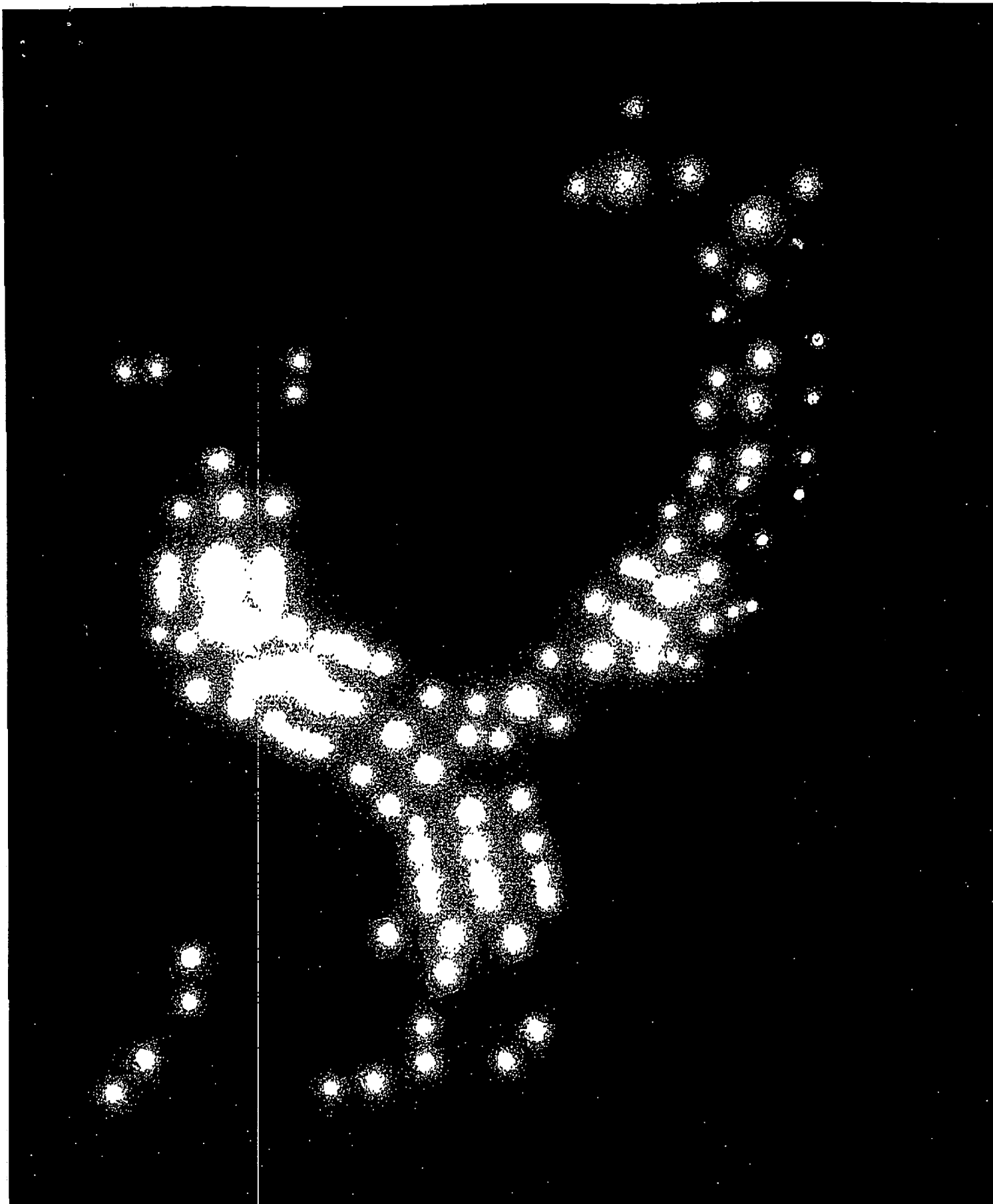
VI. Handling and Shipping Information

Shipping Data	Gulftene 4 Butene-1	Gulftene 6 Hexene-1	Gulftene 8 Octene-1	Gulftene 10 Decene-1	Gulftene 12 Dodecene-1
Lb./Gal. at 60F	5.008	5.64	6.00	6.21	6.36
Container and Net Weight (lbs.)					
5-Gallon Pail (Epoxy Lined), net weight	Not Available	26	28	30	30
55-Gallon Drum (Epoxy Lined), net weight	Not Available	310	330	342	350
Bill of Lading Commodity Description:					
Pails and Drums	—	Petroleum Naphtha- Flammable Liquid		Petroleum Naphtha	
Tank Truck or Tank Car	Liquified Petroleum	Petroleum Naphtha-		Combustible	
	Gas-flammable Compressed	Flammable Liquid		Liquid N.O.S. Petroleum Naphtha	
	Gas-Butene-1				
Dot Classification	Flammable Compressed Gas	Flammable Liquid		Combustible Liquid N.O.S.	
Railroad Shipping Point	Eldon, Texas				
Railroad Carrier	Southern Pacific				
Truck Location	Cedar Bayou, Texas				



Gulftene 14 Tetradecene	Gulftene 16 Hexadecene	Gulftene 18 Octadecene-1	Gulftene 20 Eicosene-1	Gulftene 20-24 Fraction	Gulftene 24-28 Fraction	Gulftene 30+ Fraction
6.46	6.54	6.60	6.66	6.67	6.83	6.95
31	32	33	33	33	34	34
356	360	363	366	366	375	380
Petroleum Naphtha			Petroleum Wax		Petroleum Wax	
Petroleum Naphtha			Petroleum Wax		Petroleum Wax	
Not Regulated			Not Regulated		Not Regulated	





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Gulfene detergent derivatives lend emolliency to synthetic detergent bars and build foam into shampoos.

VIII. Sales Offices

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U. S. Steel Building

600 Grant St.

P. O. Box 1166

Pittsburgh, PA 15230 Telephone (412) 263-5129

Houston

915 Esperson Building

P. O. Box 3766

Houston, TX 77001 Telephone (713) 750-3280

General Office

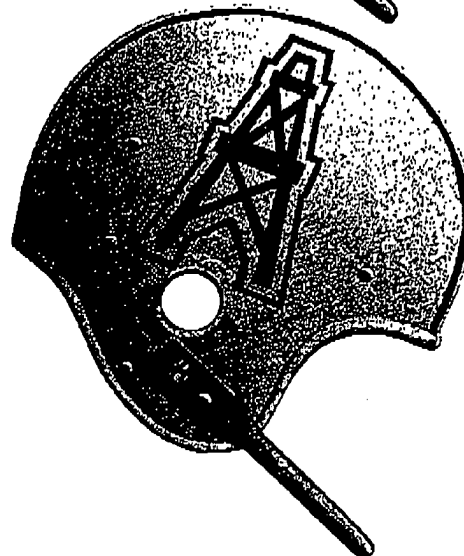
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2 Houston Center

P.O. Box 3766

Houston, TX 77001

Telephone (713) 750-2847
(713) 750-3078



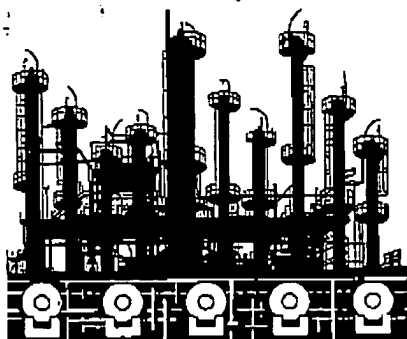
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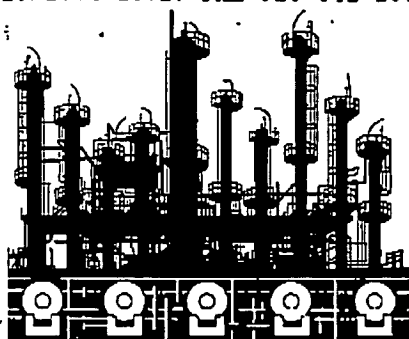
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Houston, Texas 77001

GULFTENE 4 BUTENE-1

PRODUCT CHARACTERISTICS	TYPICAL ANALYSES	SALES SPECIFICATIONS
Butene-1: Wt. % Gulf 1028	98.5	min. 98.0
Saturated Hydrocarbons: Wt. % Gulf 1028	1.4	max. 1.8
Cis and Trans Butene-2: Wt. % Gulf 1028	0.1	max. 0.1
Isobutane: Wt. % Gulf 1028	<0.05	max. 0.05
Other Hydrocarbons: Wt. % Gulf 1028	<0.1	max. 0.1
Water: PPM by Wt. Gulf 967	15	max. 15
Acetylenes: PPM Gulf 1138	<1	max. 5
Sulfur: PPM Gulf 834	<1	max. 1

Product Information Sheet AO 4-473 st



GulfteneTM Alpha Olefin Data

GulfteneTM Alpha Olefins

Gulf Oil Chemicals Company

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GULFTENE 6 HEXENE-1

PRODUCT CHARACTERISTICS

TYPICAL VALUE

SALES SPECIFICATION

Specific Gravity, D^a1298: 60°/60°F.

0.678

Flash, P-M: °F.

bel. 60

Color, Saybolt

+30

Appearance, Gulf 498: 70°-80°F.

passes

not darker than +30
clear and free of
visible impurities

Water, Gulf 525: PPM

<25

n-Alpha Olefins, Gulf 1027: Wt. %

97.0

max. 25

Monoolefins, Gulf 1027: Wt. %

98.6

min. 96.0

Vinylidenes, Gulf 1027: Wt. %

1.3

min. 98.5

Olefins Other Than n-Alpha and

max. 1.75

Vinylidenes, Gulf 1027: Wt. %

0.2

max. 1.0

Saturates, Gulf 1027: Wt. %

1.4

max. 1.5

Carbon No., Gulf 1030: Wt. % C₈

99.8

min. 99

Below C₄ and Above C₈

<0.10

max. 0.10

Peroxides as Active Oxygen, Gulf 1151: PPM

<1.0

max. 1.0

Distillation, D^a1078

5% Cond. at: °C.

60

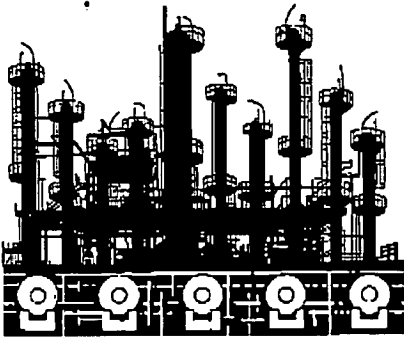
95

66

^aASTM Method

This product can be included in blends within tolerances of ±5% by weight.

Product Information Sheet No AO 6-568 st



Gulftene[™] Alpha Olefin Data

Gulftene[™] Alpha Olefins

Gulf Oil Chemicals Company

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GULFTENE 8

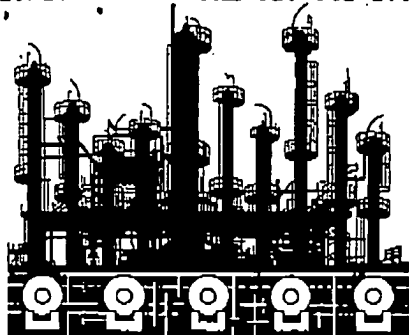
OCTENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D ^a 1298: 60°/60°F.	0.719	—
Flash, P-M: °F.	bel. 60	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Water, Gulf 525: Wt. %	0.01	max. 0.02
n-Alpha Olefins, Gulf 1029: Wt. %	96.1	min. 95.5
Monoolefins, Gulf 1029: Wt. %	98.6	min. 98.5
Saturates, Gulf 1029: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C ₈	99.7	min. 99
Distillation, D ^a 1078		
5% Cond. at: °C.	118	—
95	128	—

^aASTM Method

This product can be included in blends within tolerances of $\pm 5\%$ by weight.

Product Information Sheet No. AO 8-867 st



Gulftene[™] Alpha Olefin Data

Gulftene[™] Alpha Olefins

Gulf Oil Chemicals Company

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GULFTENE 10

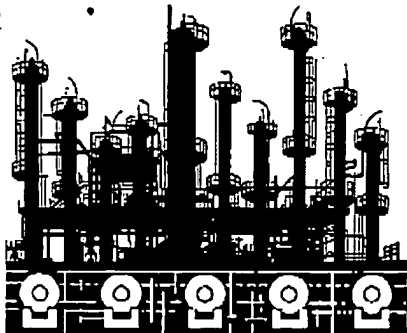
DECENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D ^a 1298: 60°/60°F.	0.745	—
Flash, P-M: °F.	120	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Water, Gulf 525: Wt. %	0.01	max. 0.02
n-Alpha Olefin, Gulf 1026: Wt. %	95.2	min. 94.6
Monoolefins, Gulf 1026: Wt. %	98.6	min. 98.5
Saturates, Gulf 1026: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C ₁₀	99.4	min. 98
Distillation, D ^a 1078		
5% Cond. at: °C.	164	—
95	175	—

^aASTM Method

This product can be included in blends within tolerances of ±5% by weight.

Product Information Sheet No. AO 10-667 st



Gulftene™ Alpha Olefin Data

Gulftene™ Alpha Olefins

Gulf Oil Chemicals Company

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GULFTENE 12

DODECENE-1

PRODUCT CHARACTERISTICS**TYPICAL
VALUE****SALES
SPECIFICATION**Specific Gravity, D^a1298: 60°/60°F.

0.763

Flash, P-M: °F.

180

Color, Saybolt

+30

Appearance, Gulf 498: 70°-80°F.

passes

not darker than +30
clear and free of
visible impurities

n-Alpha Olefins, Gulf 1026: Wt. %

94.0

min. 93.6

Monoolefins, Gulf 1026: Wt. %

98.6

min. 98.5

Saturates, Gulf 1026: Wt. %

1.4

max. 1.5

Carbon No., Gulf 1030: Wt. % C₁₂

99.3

min. 97

Distillation, D^a1078

5% Cond. at: °C.

205

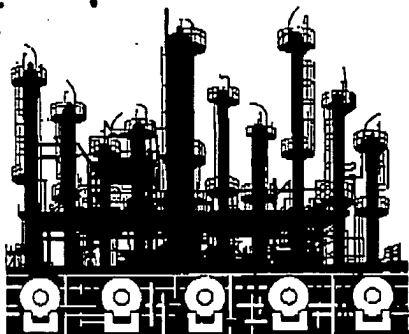
95

220

^aASTM Method

This product can be included in blends within tolerances of ±5% by weight.

Product Information Sheet No. AO 12-667 st



Gulftene™ Alpha Olefin Data

Gulftene™ Alpha Olefins

Gulf Oil Chemicals Company

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GULFTENE 14

TETRADECENE-1

PRODUCT CHARACTERISTICS**TYPICAL
VALUE****SALES
SPECIFICATION**Specific Gravity, D²⁰₁₂₉₈: 60°/60°F.

0.776

Flash, P-M: °F.

225

Color, Saybolt

+30

Appearance, Gulf 498: 70°-80°F.

passes

not darker than +30
clear and free of
visible impurities

n-Alpha Olefins, Gulf 1026: Wt. %

93.0

min. 92.6

Monoolefins, Gulf 1026: Wt. %

98.6

min. 98.5

Saturates, Gulf 1026: Wt. %

1.4

max. 1.5

Carbon No., Gulf 1030: Wt. % C₁₄

98.9

min. 96

Distillation, D²⁰₁₀₇₈

5% Cond. at: °C.

240

95

255

*ASTM Method.

This product can be included in blends within tolerance of ±5% by weight.



GulfteneTM Alpha Olefin Data

GulfteneTM Alpha Olefins

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GULFTENE 16

HEXADECENE-1

PRODUCT CHARACTERISTICS

TYPICAL VALUE

SALES SPECIFICATION

Specific Gravity, D¹²⁹⁸: 60°/60°F.

0.785

—

Flash, P-M: °F.

270

—

Color, Saybolt

+30

not darker than +30

Appearance, Gulf 498: 70°-80°F.

passes

clear and free of
visible impuritiesFreezing Point, D¹⁰¹⁵: °C.

4

—

n-Alpha Olefins, Gulf 1026: Wt. %

92.0

min. 90.6

Monoolefins, Gulf 1026: Wt. %

98.6

min. 98.5

Saturates, Gulf 1026: Wt. %

1.4

max. 1.5

Carbon No., Gulf 1030: Wt. % C₁₆

98.5

min. 95

Distillation, D¹⁰⁷⁸

5% Cond. at: °C.

270

—

95

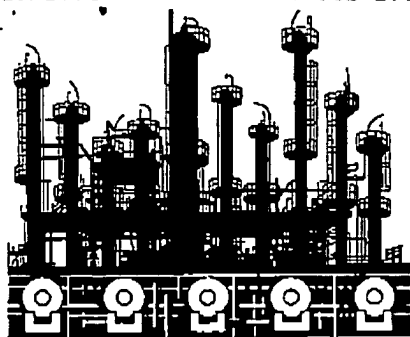
300

—

^aASTM Method

This product can be included in blends within tolerances of ±5% by weight.

Product Information Sheet No. AO 16-667 st



Gulftene™ Alpha Olefin Data

Gulftene™ Alpha Olefins

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GULFTENE 18

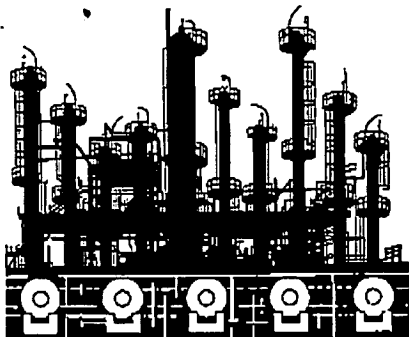
OCTADECENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D ¹²⁹⁸ : 60°/60°F.	0.792 ^b	—
Flash, P-M: °F.	310	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Freezing Point, D ¹⁰¹⁵ : °C.	18	—
n-Alpha Olefins, Gulf 1026: Wt. %	90.8	min. 88.6
Monoolefins, Gulf 1026: Wt. %	98.6	min. 98.5
Saturates, Gulf 1026: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C ₁₈	98.0	min. 94

^aASTM Method^bTheoretical: Converted from melted liquid gravity to 60°F. by means of ASTM-IP Petroleum Measurement Tables. Determine gravity at least 20°F. above freezing point.

This product can be included in blends within tolerance of ±5% by weight.

Product Information Sheet No. AO 18-657 st



Gulftene™ Alpha Olefin Data

Gulftene™ Alpha Olefins

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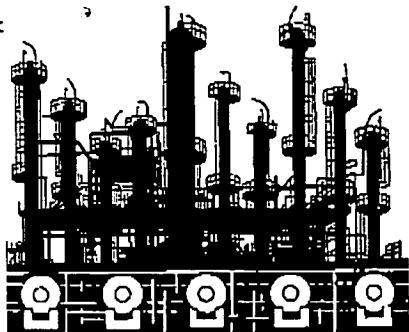
GULFTENE 20-24

C₂₀-C₂₄ ALPHA OLEFIN FRACTION

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATIONS
Carbon No., Gulf 1030: Wt. %		
C ₁₈	1	max. 3
C ₂₀	49	45-55
C ₂₂	42	31-47
C ₂₄	8	max. 15
C ₂₆	<0.1	max. 1
Gravity, Liquid State: Theor.		
°API	45.5	—
Sp. Gr., 60°/60°F.: D ^a 1298	0.799 ^b	—
Viscosity, SUV: Sec.		
210°F.	33.2	—
Viscosity, Kin.: Cs.		
210°F.	2.10	—
Melting Point, D 127: °F.	110	—
Haze Point, °F.	85	—
Flash COC: °F.	375	—
Color, Saybolt	+30	—
Saturates, Gulf Method: Wt. %	1.4	—

^a ASTM Method^b Converted from melted liquid gravity to 60°F. by means of ASTM-IP Petroleum Measurement Tables. Determine gravity at least 20° above freezing point.

Product Information Sheet No. AO 20-24 - 877 st



Gulftene™ Alpha Olefin Data

Gulftene™ Alpha Olefins

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GULFTENE 24-28

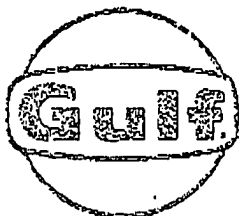
C₂₄-C₂₈ ALPHA OLEFIN FRACTION

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATIONS
Carbon No., Gulf 1030: Wt. %		
C ₂₂	1	max. 4
C ₂₄	30	24-36
C ₂₆	39	32-42
C ₂₈	20	15-25
C ₃₀ +	10	max. 17
Gravity, Liquid State: Theor.		
°API	41.3	—
Sp. Gr., 60°/60°F.: D-1298	0.819 ^a	—
Viscosity, SUV; Sec.		
210°F.	34.5	—
Viscosity, Kin.: Cs.		
210°F.	2.50	—
Melting Point, D 127: °F.	145	—
Haze Point, °F.	150	—
Flash, COC: °F.	380	—
Color, Saybolt	+15	—

^aASTM Method

^bConverted from melted liquid gravity to 60°F. by means of ASTM-IP Petroleum Measurement Tables.
Determine gravity at least 20°F. above freezing point.

Product Information Sheet No. AO 24-28 - 877 st



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SP-14023-07